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JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

PASADENA, CALIFORNIA

ENGINEERING PLANNING DOCUMENT

NO. 45

SPACE FLIGHT OPERATIONS MEMORANDUM

RANGER I

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JET PROPULSION LABORATORY

CALIFORNIA INSTITUTE OF TECHNOLOGY

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I. INTRODUCTION

A. Purpose

The purpose of the Space Flight Operations Memorandum (SFOM) is to summarize, on the basis of the information available at this time, the following:

1) Performance of the Space Flight Operations Complex (SFOC).

2) Performance of Atlantic Missile Range (AMR), Deep Space Instrumentation Facility (DSIF), Launch Operations Directorate (LOD), North American Air Defense Command (NORAD), and JPL Launch Checkout Telemetry Trailer (LCTT) in tracking and communicating with the spacecraft.

3) Analysis of the scientific telemetry data.

4) Spacecraft performance.

5) Orbital data.

B. General

Ranger I* was launched at 10 hours 4 minutes and 10.26 seconds GMT on 23 August 1961, completed 110 orbits, each of approximately 90 minutes' duration, and reentered the Earth's atmosphere during its 111th orbit on 30 August 1961.

II. SPACE FLIGHT OPERATIONS COMPLEX

The Space Flight Operations Complex (SFOC) responded to the highly nonstandard RANGER I mission in a most satisfactory manner. After initial acquisition by the DSIF and establishment of the fact that the spacecraft was in a nonstandard Earth satellite orbit, the DSIF attempted to track the spacecraft on each visible pass. The Central Computing Facility (CCF) was able to reduce all usable near-real time telemetry data obtained by the DSIF. The magnetic tapes of the telemetry recorded by the DSIF sites were returned to the DRL at JPL for reduction.

III. AMR PARTICIPATION IN TRACKING RANGER

The AMR was assigned the responsibility of providing JPL with 1) orbital elements of the parking and transfer orbits, 2) acquisition angles for DSIF #1 and #5, and 3) raw data for the backup role by JPL.

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* In its launch configuration, the Atlas/Agena/Ranger is identified as Ranger-1, NASA Mission P32. The Ranger spacecraft, designated as RA-1, when in successful orbit becomes Ranger I.

TABLE I. ORBITAL ELEMENTS

Orbital Element*	Computed By	Parking Orbit		Transfer Orbit	
		AMR	JPL	AMR	JPL
	Data Source	Antigua	Antigua and Ascension	Ascension	Ascension and DSIF
Semi-major Axis of Conic Section (a, km)		6598.03	6580.0	6709.7	6708.9
Eccentricity of Conic Section (e)		0.0071	0.0052	0.0251	0.0249
Inclination (i degrees)		32.72	32.85	32.93	32.93
Right Ascension of Ascending Node (Ω degrees)		279.81	279.80	279.81	279.82
Argument of Perigee (ω degrees)		172.41	194.6	198.07	198.36
True Anomaly Plus Argument of Perigee at Epoch ($V + \omega$ degrees)		141.40	136.5	197.03	197.0133

* See Table 3. of the Space Flight Operations Plan RANGER 1 (EPD 18) for explanations of the various orbital element definations.

III. AMR PARTICIPATION IN TRACKING RANGER (CONT'D)

The orbital elements were supplied to JPL, but not at the time required. The elements are shown in Table I. A meeting was planned between JPL and AMR to coordinate and improve the operations in this area for RA-2.

It is believed that the delay in supplying the parking orbit was caused by the necessity of having to first supply look angles to the DAMP ship (Downrange Anti-Ballistic Measurement Program) and to Ascension Island. The loss of the use of the "Twin Falls Victory" (Pershing) tracking ship with its FPS-16 and high data rate (10 points per second) resulted in the attempt to form an orbit with too few Antigua data. The computing facility at AMR lost the use of the majority of the good Antigua data during this computation time. The lost data was subsequently retransmitted and a good orbit resulted.

The transfer orbit using Ascension data was delayed by 1) difficulty in rejecting bad data which was caused by "beacon-stealing" by the DAMP ship, 2) poor radio data transmission conditions, and 3) lack of available telemetry defining the time of second Agena burn. When the data was edited and an assumed nominal time of second Agena burnout chosen, a good orbit resulted.

The raw data from AMR reached JPL with very few transmission errors. Although the Antigua data had no transmission errors, it was not used by JPL because of an input error in the 7090. The Ascension data, however, was used by JPL in real time to compute the initial orbit.

IV. DSIF PARTICIPATION

The primary tracking load for this nonstandard orbit was borne, as previously planned for such an occurrence, by the Goldstone Az El Station and the Mobile Tracking Station. The Woomera and Johannesburg Stations were secured for the first day as soon as it became apparent that the spacecraft was in a near-Earth orbit. The majority of the passes at these stations were either in an area where the antenna could not track or where they crossed at angular rates that exceeded the capabilities of the stations. The Az El mounted antennas at Goldstone and the Mobile Tracking Stations had the rate capabilities necessary to obtain tracking data for orbit determination. After the orbit had been determined, the Johannesburg and Woomera Stations were put back in operation and obtained valuable information on many orbits. Table II presents the possible view periods from the DSIF stations and the periods which were tracked by the DSIF.

Attempts to track were made on 60 orbits, most of which were successful. By successful it is meant that either some position or telemetered information was obtained. The DSIF did better than expected considering the angular rates that were experienced because of the low orbit.

TABLE II. 1

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{OT}	IN	OUT	T_{OT}	IN	OUT	T_{OT}	DBM	TIME
Aug. 23	1	1	103611	104201	-								
	5	1	103931		-								
	3	1	113133		-								
	2	1	113526	113535	00:11								
	1	2	121131	121841	07:10				121141	121841	07:00		
	2	2	130822	131426	06:04				130822	131426	06:04		
	3	2	130815	131452	06:37				130815	131430	06:15		
	1	3	134657	135551	08:54				134657	135551	08:54	-116	134647
	1	4	152220	152640	04:20				152241	153231	09:50	-116	152220
												-111	152828
	1	5	165951	170801	08:10							-114	165945
Aug. 24	3	14	052555	052735	01:40								
	2	15	065912		-				065912	070142	02:30	-130	065912
	3	15	065829	070659	08:30								
	2	16	083241	084111	08:30							-116	
												- 97	Maximum
	1	16	091439	092013	05:34				091500	092013	05:13	-116	091500
	2	17	100832	101652	08:20				101502	101652	01:50	- 95	Average
	3	17	100920	101810	08:50				100940	101730	07:50	-100	
												-70	Maximum

TABLE II.2

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY IN	R.F. ONE-WAY OUT	R.F. ONE-WAY T_{O_T}	R.F. TWO-WAY IN	R.F. TWO-WAY OUT	R.F. TWO-WAY T_{O_T}	AUTOTRACK IN	AUTOTRACK OUT	AUTOTRACK T_{O_T}	SIGNAL DBM	SIGNAL TIME
Aug. 24	1	17	104851	105600	07:09				105204	105559	03:55	-128	
												- 94	Maximum
	2	18	114442	114952	05:10								
	3	18	114500	1148[illegible]1	03:21	1148[illegible]0			114520	114821	03:01		
	1	18	122525	122545	00:20	122545	123931	13:46	122631	123221	05:50	-117	122545
	1	19	140031	140051	00:20	140051	140910	08:19	140101	140910	08:09	-112	
	1	20				153601	154501	08:50	153601	154501	08:50	-110	153540
	5	20	153800										
	1	21	171321	171322		171[illegible]	171821	05:59	171321	171821	05:00	-117	171220
Aug. 25	4	27	015010									-140	015010
	4	28	032500	032825	03:25							-105	032620
	4	29	050627	050637	00:10							-135	
	2	29											
	3	29	053850	054030	01:40				053900	054010	01:10	- 90	053900
	4	30	063550	064330	07:40				063550	064320	07:30		
	2	30	070711	070951	02:40				070941	070951	00:10		
	3	30	070729	070749	00:20				070739	070749	00:10		
			071039	071619	05:40				071249	071609	03:20		

TABLE II. 3

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY IN	R.F. ONE-WAY OUT	R.F. ONE-WAY TOT	R.F. TWO-WAY IN	R.F. TWO-WAY OUT	R.F. TWO-WAY TOT	AUTOTRACK IN	AUTOTRACK OUT	AUTOTRACK TOT	SIGNAL DBM	SIGNAL TIME
Aug. 25	1	31	074921	074931	00:10							-132	074921
	4	31	081101	081721	06:20							-140	
												-115	
	2	31	084351	085021	06:30				084351	085021	06:30	- 90	084600
	3	31	084749	085129	04:30							-106	085030
	1	32	092201	092841	06:40				092221	092801	06:40	-114	092201
												- 94	092547
	5	32	092311	092621	03:10				092331	092451	01:20	-130	092540
	2	32	101741	102601	09:40				101751	102551	08:00		
	3	32	101759	101859	01:00	101859	102619	07:20	101849	102619	07:30		
	1	33				105733	110413	06:40	105821	110341	05:20	-123	105733
												- 94	110037
	2	33	115321	115951	06:30				115331	115951	06:20	- 95	115958
	3	33	115329	115729	04:00	115729	120039	03:10	115729	120029			
	1	34	123248	123258	00:10	123258	124021	07:23	123310	124001	06:51	-100	123415
												- 96	123800
	1	35	140811	141631	08:20				140821	141621	08:00	-113	140813
	5	35	140959	141124	01:25				140959	141124	01:25	- 80	140959

TABLE II. 4

TRACKING CHART

DATE	STA	ORB	R F ONE WAY IN	R F ONE WAY OUT	R F ONE WAY T_{O_T}	R F TWO WAY IN	R F TWO WAY OUT	R F TWO WAY T_{O_T}	AUTOTRACK IN	AUTOTRACK OUT	AUTOTRACK T_{O_T}	SIGNAL DBM	SIGNAL TIME
Aug. 25	1	36	154248	155138	08:50				154431	155138	07:07	-125	154430
												-100	154947
	5	36	154400	154410	00:10								
			154457	154521	00:30								
			154551	154721	01:30								
Aug. 26	4	42	002424	002434	00:10							-112	During
												-145	Lock
	4	43	015433	020033	06:00				015433	020023	05:50	- 68	Maximum
	4	44	032921	033609	06:48				032939	033509	05:30	- 70	Maximum
	4	45	050516	051116	06:00								
	3	45	053619	053629	00:10	053629	054409	07:40	053659	054359	07:00	- 94	053811
	2	45	053645	054222	05:37							-110	054144
	4	46	063914	064614	07:00								
	3	46	070951	071219	02:28	Pseudo 071219	071949	07:30	071209	071909	07:00	- 80	071714
	2	46	071005	071821	08:16				071041	071941	07:00	- 80	071610
	1	47	075041	075631	05:50				075041	075551	05:10	-112	075041
												- 85	072251
	5	47	075141	075701					075141	075211	00:30		
	3	47				Pseudo 084459	085029	05:30	084619	085019	04:00	- 88	084950

TABLE II. 5

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{OT}	IN	OUT	T_{OT}	IN	OUT	T_{OT}	DBM	TIME
Aug. 26	2	47				Pseudo 084541	084931	03:50				- 84	084906
	1	48	092604	093135	05:31				092701	092911	02:10	-125	092604
												- 90	Maximum
	3	48	102019	102129	01:10	102129	102309	01:40	102109	102249	01:40	-130	Range
			102309	102838	05:26							-100	
	2	48	102051	102751	02:00				102111	102741	06:30		
	1	49	110020	110638	06:18				110046	110621	05:35	-116	110020
												- 94	Maximum
	2	49	115551	115939	03:12				115601	115931	03:30		
	3	49	115624	115709	00:45	115709	120203	04:54	115709	120149	04:40	- 94	115755
	1	50	123511	123547	00:36	123547	124238	06:51	123624	124201	05:37	-100	123511
												- 71	Maximum
	1	51	140940	141755	08:15				141014	141751	07:37	-100	140940
												- 92	Maximum
	5	51	141041	141741	07:00				141041	141731	06:50		
	1	52	154514	155111	05:57				154614	154731	01:17	-117	154514
												-104	Maximum
Aug. 27	4	58	002036	002436	04:00				002346	002436	00:50	- 80	Maximum
	4	59	015315	015835	05:20				015325	015655	03:30	- 65	Est. Max

TABLE II. 6

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{O_T}	IN	OUT	T_{O_T}	IN	OUT	T_{O_T}	DBM	TIME
Aug. 27	4	60	032902	033342	04:40							- 90	Maximum
	3	60	040319										
	4	61	050326	050836	05:10				050356	050646	02:50	-110	Maximum
	2	61	053541	054011	04:30				053601	054011	04:10	- 95	053807
	3	61	053711	053741	00:30	053741	054121	03:40	053741	054121	04:40	- 97	054008
	4	62	(063807)										
	2	62	071001	071041	00:40							-125	071000
	3	62	071309	071359	00:50							-120	071600
	1	63	074621	074751	01:30				074621	074751	01:31	-116	
	3	63	084141	085031	08:50				084151	085001	08:10	- 84	084720
	2	63	084141	084941	08:00				084201	084941	07:40	- 85	084630
	1	64	092221	092731	05:10				092241	092731	04:50	-116	092242
	3	64	101649	102419	07:20				101659	102359	07:00	- 94	102320
	2	64	101641	102311	06:30				101651	102311	06:20	- 88	101930

TABLE II. 7

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{OT}	IN	OUT	T_{OT}	IN	OUT	T_{OT}	DBM	TIME
Aug. 27	1	65	105641	110221	05:40				105711	110201	04:50	-121	105701
	1	66	123041	123741	07:00				123111	123721	06:10	-120	
	1	67	140441	141151	07:10				140521	141111	05:50		
	5	67	140601	140741	01:40				140631	140741	01:10	-130	Average
Aug. 28	4	74	001225	001545	03:20							-130	
	4	75	014426	014746	03:20				014426	014716	02:50	- 70	Maximum
	4	76	031954	032104	01:10				031954	032104	02:10	- 80	Maximum
	3	76	035400	035520	01:20				035400	035520	01:20	-100	035534
	4	77	045237										
	3	77	052539	053049	05:10				052539	053049	05:10	- 90	052844

TABLE II. 8

TRACKING CHART

DATE	STA	ORB	R.F. ONE-WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{OT}	IN	OUT	T_{OT}	IN	OUT	T_{OT}	DBM	TIME
Aug. 28	1	78	060241	060811	05:30				060301	060751	04:50	-121	
	4	78	062728	062828	01:00							-130	During Lock
	3	78	070109	070149	00:40							-125	Maximum
												-130	070129
	1	79	073551	074141	05:50				073621	074141	05:20	-113	073612
												-100	Maximum
	5	79	073600									-117	
	3	79	083049	083839	07:50				083059	083819	07:20	- 92	083400
	1	80	091131	091551	04:20				091201	091511	03:10	-113	
	3	80	100459	101159	07:00				100519	101129	06:10	- 95	100803
	1	81	104441	105021	05:40				104511	105001	04:50	-113	104441
													104845
	1	82	121811	122451	06:40				121821	122401	05:40	-119	
												- 95	Maximum
	5	82	121900										
	1	83	135211	135821	06:10				135251	135741	04:50	-121	
	5	83	135241	135521	02:40				135341	135511	01:30	-117	Maximum
	4	89	235336									-110	Maximum

TABLE II. 9

TRACKING CHART

DATE	STA	ORB	R.F. ONE WAY			R.F. TWO-WAY			AUTOTRACK			SIGNAL	
			IN	OUT	T_{O_T}	IN	OUT	T_{O_T}	IN	OUT	T_{O_T}	DBM	TIME
Aug. 29	4	91	(012944)										
	4	92	(030254)										
	3	92	(033731)										
	4	93	(043541)										
	3	93	(050137)										
	4	94	(061002)										
	1	94	(062500)										
	3	94	(063341)										
	1	95	(0[illegible]000)										

IV. DSIF PARTICIPATION (CONT'D)

On Orbit 30, 25 August, the Goldstone Az El Station transmitted the Antenna Switch-Over Command, switching the transponder from the high-gain antenna to the omniantenna. On Orbit 31, 25 August, this command was transmitted twice by Goldstone switching the transponder back and forth between the omniantenna and the high-gain antenna.

On Orbits 46 and 47, 26 August, the Hinge Override Command was transmitted by the DSIF 2, Goldstone HA Dec Station. On Orbit 49, 26 August, the Roll Override Command was transmitted by this station. These commands were transmitted primarily to test this station's backup capability.

Except for short intervals, while Ranger I was passing over South Africa on subsequent orbits, Orbit 61, 27 August, was the last orbit during which the transponder signal and the high-rate telemetry were observed. The majority of the time, all stations had been tracking the transponder since only the low-rate telemetry had been available on the beacon.

On Orbit 91, 29 August, Woomera attempted the first track of the day with negative results. A search was made by all stations the rest of the day but neither the transponder nor beacon frequencies were heard. It was concluded that the beacon power supply had failed. The DSIF was secured.

Two temporary modifications were made to the Woomera, Johannesburg, and Goldstone HA Dec Stations to increase their tracking capabilities: 1) the servo hydraulic system was re-plumbed to take out the anti-backlash feature, thereby increasing the tracking rate capability from 1° per second to 1.5° per second with reduced tracking accuracy, and 2) the receiver reference channel was connected to the 6-foot calibration dish that is mounted on the side of the main antenna. Although this modification reduced the system gain by 20 db, it increased the beam width to 10 degrees but left the tracking beam width at approximately 1 degree.

V. LOD PARTICIPATION

The LOD microlock tracking station at Cape Canaveral supplied, in addition to launch data, one-way doppler data for all passes within their line of sight through 30 August 1961. LOD also recorded certain telemetry data on magnetic tape.

VI. NORAD PARTICIPATION

Ranger I and the Agena were skin-tracked throughout their lifetimes by the tracking facilities of NORAD. The NORAD Trinidad Station tracked from launch and promptly supplied data indicating that spacecraft-Agena separation had occurred. After loss of communication with Ranger I by the DSIF on 29 August 1961, skin-tracking was continued by NORAD.

VI. NORAD PARTICIPATION (CONT'D)

NORAD has indicated that Ranger I reentered the Earth's atmosphere on Orbit 111 which would have been completed at approximately 0900 GMT, 30 August 1961. The last contact made with Ranger I was by NORAD's Laredo, Texas site at approximately 0830 GMT, 30 August 1961. At that time, Ranger I's altitude was estimated at approximately 70 statute miles above the Earth's surface.

VII. LCTT PARTICIPATION

Although it had not been planned to use the LCTT to track beyond the launch phase, a minimum crew maintained a continuing effort from launch through the early hours of 27 August 1961. Additionally, one command was sent to the spacecraft by the LCTT, successfully effecting antenna changeover from omni- to high-gain.

VIII. SCIENTIFIC TELEMETRY

All the Channel B-13 data from AMR, Goldstone, and Woomera has been reduced and distributed to the experimenters. Reduction of data from MTS and Channels B-10, B-11, and B-12 has not yet been completed.

Data Automation System. This system operated correctly with the following minor exceptions:

1) There was an occasional complete reset of all data registers between successive passes--perhaps caused by spacecraft power transients.

2) There was an occasional program reset within the DAS (i.e.,it would start a new frame without finishing the one it was on) of undetermined origin.

3) There was an occasional addition of 32 counts to the frame-count register between passes.

4) There was an occasional malfunction of the ion chamber time register, probably caused by noise.

Ion Chamber, Triple Coincidence Telescopes, Gold Silicon Detector, and Geiger Tube. All appeared to have operated approximately as expected in the satellite environment.

Cadmium Sulfide Detectors B and C. These detectors are nearly identical in construction, location, and view angle--differing only in that Detector C has a magnetic broom for preventing low energy electrons from

VIII. SCIENTIFIC TELEMETRY (CONT'D)

being counted. Thus, Detector B should count at a rate equal to or greater than Detector C; however, Detector C consistently had the much higher counting rate. The data are currently being studied in detail to try to find an explanation of this discrepancy. There was a similar, but smaller, discrepancy between Detectors A and D.

Micrometeorite Detectors. Anomalously high counting rates were often recorded by the light flash detector when the spacecraft was in the sunlight. This is presumably due to direct or reflected sunlight and/or Earth light. The instrument operated correctly when in the dark.

Electrostatic Analyzers. These appear to have operated normally. However, the data are very abnormal, probably due to the presence of the ionosphere. Much more study of the data is required.

Lyman Alpha Telescope. Part or all of four pictures and several in-flight calibrations were observed as well as background measurements of Lyman Alpha intensity. There are no indications to date of any malfunction.

Magnetometer. No magnetic field data were obtained, both because the Earth's field at the Ranger I altitude was higher than could be measured with this experiment and because the magnetometer temperature was usually outside the operational range.

Vela Hotel. This experiment apparently operated correctly when the Vela Hotel solar panels received enough sunlight. Most passes were too short to obtain any useful data.

IX. SPACECRAFT PERFORMANCE

Present knowledge of the spacecraft performance indicates that separation from the Agena appears to have been normal.

The spacecraft controller commands were all executed. The exact times are not known but there is no reason to believe the times were not nominal.

The following indications of a malfunction were noted:

1) The attitude control converter voltage measurement was at zero (0) volts.

2) The sun sensor and light detector outputs were at zero, substantiating the above.

IX. SPACECRAFT PERFORMANCE (CONT'D)

3) The rate gyro measurements had slightly more than two spikes per second. The attitude control converter appeared to have returned to normal by the first pass on 25 August 1961.

The attitude control system was inoperative on 24 August. While it was apparent that the attitude control gas was exhausted by 25 August, it was suspected that it had been exhausted by 24 August. Because of the above conditions, there were no opportunities to observe the attitude control system in action after the first day of the mission. An attempt is being made to determine if the attitude control performance was normal for a Ranger spacecraft in a near-Earth satellite orbit.

The communication system functions appear to have been qualitatively normal. The radio command to transfer from the omni-antenna operation to high-gain antenna operation was sent four times and was successful each time. All commands were sent by Goldstone except the one sent by the JPL LCTT.

Spacecraft temperatures appear to have been normal for a spacecraft on this orbit.

The solar panels and the Solar Corpuscular Radiation boom were extended successfully. This is deduced from the temperature and solar panel currents data since the blip channel was inconclusive.

The friction experiment was turned on and operated for 17 hours. Data was received and is being analyzed.

X. ESTIMATION OF THE ORBIT OF RANGER I

Table III presents the orbital parameters for Ranger I. These, not the best possible, are the best obtainable using the Orbit Determination Program (ODP) for RA-1 and 2 with angle data only. The ODP, designed for use with deep space probes similar to the RA-1 standard trajectory, lacks certain features which are mandatory for the determination of orbits of low-altitude satellites. Consequently, Dr. J. W. Siry of Goddard Space Flight Center has been requested to determine the final orbit of Ranger I, using the techniques he has developed for this purpose. Further effort will not be expended at JPL in this area.

The largest source of error in the orbital parameters found in Table III is due to the exclusion of any type of drag effect which would compensate for that experienced by the spacecraft during the decay of its orbit. This fact makes it desirable to redetermine the orbit for each excursion about the earth, and necessary to minimize the number

X. ESTIMATION OF THE ORBIT OF RANGER I (CONT'D)

of excursions based upon a single set of orbital parameters. The next largest, known source of error in these parameters is the exclusion of frequency data. Some of the good frequency data of each type was obtained during some view period by one of the DSIF stations. Difficulties, gradually being resolved, have been experienced in attempts to include this type of data. However, the nature of the orbit should minimize the contribution of error from this source. The last known source of error is due to the inherent difficulties experienced by the DSIF when attempting to track Ranger I. The overwhelmingly powerful signal coupled with the high frequency and angular rates (conditions for which the DSIF antennas were not designed) made it extremely difficult to obtain good tracking data during every view period and not to track side lobes.

Compromising these factors, a new set of orbital parameters is given for each day Ranger I was tracked. The epoch on each day was chosen to be just prior to the start of the set of new periods at Woomera. The orbit defined by these parameters should not be used beyond the last new period at South Africa. Thus, each orbit is designed to be applicable for approximately 14 hours. Clearly, as time moves away from the epoch of injection on each day, the spacecraft orbit decays further, and the orbit determined by the orbital parameters in Table III degenerates.

TABLE III. ORBITAL PARAMETERS OF RANGER I

1961 Mo-Day	Time of Injection X / R	Y / ϕ	Z / θ	$\dot{X}$ / V	$\dot{Y}$ / γ	$\dot{Z}$ / σ	Epoch of Pericenter Passage a / e	i / Ω	ω / ν	Period / Apogee / Perigee
	8-23-61, 10h 26m 36 sec						8-23-61, 10h 27m 23.106 sec			91.1483
8-23	-.24370486E4 .65421648E4	.60054081E4 -.78371254E1	-.89207321E3 .34396299E3	-.59845351E1 .75058997E1	-.30579307E1 -.83381240E-1	-.41566759E1 .12400118E3	.6709.03 .024911	32.9283 279.8169	197.788 -3.2601	313.337 105.597
	8-24-61, 5h 20m 0 sec						8-24-61, 4h 38m 42.202 sec			90.8346
8-24	.15937675E4 .68277538E4	-.66002189E4 .60346574E1	.71780167E3 .23132487E3	.61159252E1 .71507338E1	.15709918E1 .34833794E0	.40379101E1 .55441858E2	6693.63 .020846	32.9237 274.1791	206.828 164.324	286.614 113.172
	8-25-61, 1h 50m 0 sec						8-25-61, 1h 47m 48.742 sec			90.4836
8-25	-.36687562E4 .65356489E4	.43113055E4 -.22215557E2	-.24710883E4 .12673406E3	-.49436339E1 .74935728E1	-.53200141E1 .19903683E0	-.30874395E1 .11633590E3	6676.37 .021334	32.9008 258.1813	215.029 9.084	277.692 100.645
	8-26-61, 0h 20m 0 sec						8-26-61, 0h 23m 29.176 sec			90.1401
8-26	-.20031846E4 .65393933E4	.59413022E4 -.16505720E2	-.18579142E4 .12961566E3	-.61797660E1 .74802883E1	-.32606133E1 -.27501244E0	-.33375849E1 .12057164E3	6659.47 .018398	32.9074 251.3796	225.978 -14.448	255.625 101.686
	8-27-61, 0h 15m 0 sec						8-27-61, 0h 22m 46.763 sec			89.7370
8-27	-.32633687E3 .65485475E4	.64037421E4 -.11718777E2	-.13300636E4 .11416857E3	-.66305933E1 .74561756E1	-.12279096E1 -.51101662E0	-.39452968E1 .12282820E3	6637.59 .016117	32.9141 254.2260	234.132 -32.182	232.818 99.806
	8-28-61, 0h 10m 0 sec						8-28-61, 0h 16m 1.986 sec			89.1915
8-28	-.13595608E4 .65346669E4	.59559554E4 -.20790533E2	-.23194963E4 .12437762E3	-.65960181E1 .74585742E1	-.26048166E1 -.32863821E0	-.32160537E1 .11758648E3	6618.66 .012979	32.9076 246.9342	245.768 -24.974	202.914 96.231

X,Y,Z,$\dot{X}$,$\dot{Y}$,$\dot{Z}$ - a right handed, earth centered, equatorial, space fixed rectangular Cartesian coordinate system. Z is assumed to lie along the earth spin axis, positive north, X is normal to Z and positive in the direction of the vernal equinox, km, km/sec.

R,ϕ,θ,V,γ,σ - a right handed, earth centered, equatorial, earth fixed rectangular Cartesian coordinate system. R is from earth center in km, ϕ is latitude measured from equatorial plane positive north in degrees, θ is longitude measured eastward from the Greenwich meridian positive eastward in degrees. V is earth fixed velocity in km/sec, γ is pitch angle of spacecraft with respect to local horizontal in degrees, σ is azimuth angle of V measured east of true north in degrees.

a - semi-major axis, km
e - eccentricity
i - inclination of orbit plane to equatorial plane, deg.

Ω - longitude of ascending node, degrees
ω - argument of perigee, degrees
ν - true anomaly, degrees

period - minutes
apogee - statute miles
perigee - statute miles

All times are in GMT